Storage of SEED COTTON in Trailers

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Storage of Seed Cotton in Trailers

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Introduction

Storage of seed cotton is necessary whenever the harvesting rate exceeds the ginning rate. The use of mechanical cotton harvesters has increased the need for seed-cotton storage in spite of recent increases in daily ginning capacity.

Seed-cotton storage has always been practiced in one form or another. Probably the most widespread form was the plantation cotton house where the tenants' daily pickings were deposited. When one or two bales had accumulated, they were loaded onto a wagon and carried to a ginnery.

Today, in areas of highly mechanized production, cotton is unloaded directly from the mechanical harvester into a trailer for hauling directly to the gin. After the trailer of cotton arrives at the gin, there usually is a delay of from a few hours to several days before the cotton can be ginned. During such delays some loads of cotton heat and suffer fiber color damage that reduces the grades of ginned lint. It is not unusual for grade reductions to lower the bale value by $10 or more.

In 1955, a 5-year study was begun at the U.S. Cotton Ginning Research Laboratory, Stoneville, to find a method of treatment that would permit storing seed cotton in trailers indefinitely without grade loss or damage. The major effort was in the area of cooling and drying loads of damp seed cotton in trailers by forced aeration. As the study developed, investigations were made into (1) methods of aerating cotton on trailers and the effectiveness of aeration in controlling load heating and fiber spotting, (2) the effectiveness and practicability of field and gin-yard drying treatments in preventing storage damage, (3) the possible causes of fiber color change and their relative importance, and (4) the effect of trailer storage on other fiber and spinning quality elements.

Relation of Moisture to Seed-Cotton Storage

Looney and Speakes,[1] in reporting conclusions from studies of storing machine-picked cotton in permanent bin structures, stated that seed cotton containing less than 14 percent of moisture can be stored

[1] Looney, Z. M., and Speakes, C. O. Conditioning and storage of seed cotton with special reference to mechanically-harvested cotton. U.S. Dept. Agr., Prod. Market. Admin., Bur. Plant Indus. Soils and Agr. Engin. 38 pp. 1952. [Processed.]

for extended periods without injury to grade or spinning qualities.

Tests and observations in the early phases of the trailer storage study showed that moisture content of the cottonseed was a more reliable index of potential damage than was seed-cotton moisture content.

The behavior of cottonseed in the seed-cotton form seemed to be identical to that reported by investigators studying the behavior of cottonseed in bulk storage, as in cotton oil mill warehouses. Altschul,[2] in describing the relation of moisture to cottonseed storage, says that viable cottonseed undergoes biological processes that result in the production of heat and that moisture is by far the predominant factor affecting the degree of biological activity.

Robertson and Campbell[3] have stated that cottonseed can be stored safely if it contains less than 10 percent of moisture (wet basis): it will deteriorate if it contains more than 14 percent; but if it contains from 10 to 14 percent, it may or may not deteriorate, depending on other factors. Some of the other factors that influence the tendency of cottonseed to heat in storage are maturity, prior damage, and the degree to which biological processes have already occurred. Some loads of cotton heated even though the initial moisture level of the seed indicated they should have been safe from heating. Measurements of moisture content after heating began were higher than before-storage measurements. This observation led to the conclusion that the seeds were absorbing moisture from trapped air brought to high humidity levels by moisture in or on the fiber.

Simpson, Adams, and Stone[4] showed that water absorption by the cottonseed takes place rapidly through the chalazal opening, more slowly through the micropyle, and almost not at all through the side wall. This work disproves a widely held belief that the fiber acts as a wick by which moisture migrates into or out of the cottonseed.

An investigation was made to determine whether dry seed cotton could be induced to heat by adding moisture to the fibers. The test was made with small lots of seed cotton (4 pounds) in metal containers insulated with cotton. At the beginning of the test, seed moisture was 11.4 percent and fiber moisture was 6.2 percent. Ambient temperature was 88° F. Water was sprinkled on the test lot as it was put into its container. After 8 days the control lot was still at 88°, its seed moisture was 10.4 percent, and its fiber moisture was 6.0 percent; whereas temperature of the test lot was 106°, its seed moisture was 18.6 percent, and its fiber moisture was 9.4 percent. This test showed conclusively that fiber moisture can migrate into dry cottonseed during storage and cause spontaneous heating.

[2] ALTSCHUL, A. M. BIOLOGICAL PROCESSES OF THE COTTONSEED. *In* Cottonseed and Cottonseed Products, A. E. Bailey, ed. pp. 157–212. Interscience Publishers, Inc., New York. 934 pp., illus. 1948.

[3] ROBERTSON, F. R., and CAMPBELL, J. G. SOME OBSERVATIONS ON THE INCREASE OF FREE FATTY ACID IN COTTONSEED. Oil and Soap 10: 146–147. 1933.

[4] SIMPSON, D. M., ADAMS, C. L., and STONE, G. M. ANATOMICAL STRUCTURE OF THE COTTONSEED COAT AS RELATED TO PROBLEMS OF GERMINATION. U.S. Dept. Agr. Tech. Bul. 734, 23 pp., illus. 1940.

Moving Air Through Seed Cotton on Trailers

One of the objectives of the seed-cotton storage study was to determine whether moving air through seed cotton on trailers was a practical method of preventing storage damage.

Six all-metal wheelless bins were used in conducting full-scale aeration tests. These bins were 20 feet long, 8 feet tall, and 8 feet wide at the top (fig. 1). They were constructed of sheet steel and had a volume of 931 cubic feet. Five bales of seed cotton could be loaded into each one, but their usual capacity was four bales when loaded from mechanical harvesters in the field.

Triangular perforated ducts were fitted into the bottoms of two bins with provisions for connecting them to a No. 40 gin fan with a free air capacity of about 8,000 c.f.m. at a power load of 30 hp. The ducts were 16 feet long, triangular in cross section with 16-inch sides, and had 34 ⅛-inch holes per square inch. Total open area of the duct surface was 26.7 square feet. Diameter of the collar and pipe connecting the duct to the fan was 16 inches with a cross-sectional area of 1.4 square feet.

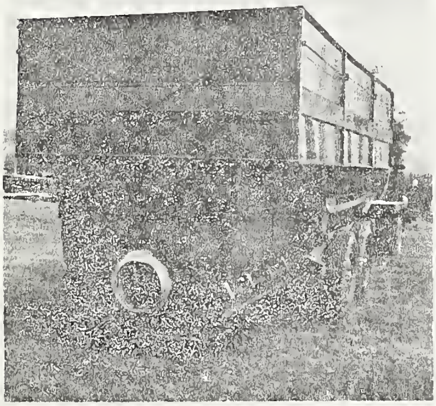

Figure 1.—Five-bale, portable bin fitted with air duct and connecting collar for forced-air ventilation.

Whenever possible, two loads were harvested simultaneously to provide a control lot for the test lot. Air was pulled through some loads only after heating was well underway and through other loads immediately upon delivery to the gin. Usually the bins were in the field all day and the sun heated the partially loaded trailer while the harvester was picking in the field. As a result the loads were warm when delivered.

The volume of air forced through the load by the fan was disappointingly low. The seed-cotton mass compacted, and fibers clogged the duct perforations as suction was applied. Shrinkage of 12 inches in depth of the load was not uncommon as air was pulled through.

Air-movement tests on a bin of cotton as received from the field showed that duct clogging reduced the effective open area to only 100 square inches, or only 2.6 percent of the original open space. The depth of the seed cotton was 6 feet; fiber moisture was 9.9 percent. Both of these factors favor packing and clogging. Only slightly more than 1,600 cubic feet of air per minute could be pulled through the load. Figure 2 illustrates the limiting effect of duct clogging on air movement when the fan-gate valve opening is no longer the controlling factor.

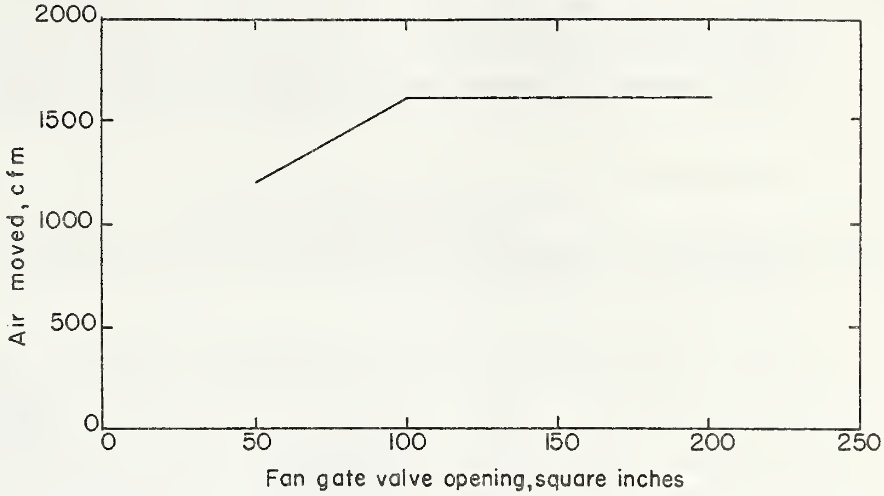

Figure 2.—Volume of air forced through load of seed cotton during suction aeration. Cotton plugging the intake duct openings limits the movement of air through the load.

These data indicated the need to change the duct-suction system. An expanded metal floor was constructed across the lower section of another bin to form a plenum chamber with an open area of 47 square feet.

Air-flow tests were made to compare the triangular duct with the plenum chamber system. Cotton in each bin was 4 feet deep, the maximum depth for the plenum chamber bin; density was about 7 pounds per cubic foot. After the pull (suction) tests had been made, the fan pipe connection was reversed and the same cotton was used in push tests.

The suction tests were made with the gate valve fully open. The plenum chamber arrangement moved a total of 4,558 c.f.m. at an approach velocity of 28 f.p.m., whereas the duct arrangement moved 2,324 c.f.m. at an approach velocity of 14 f.p.m. (table 1). The air moved per square foot of open area was almost identical for both duct and plenum systems, the flow for the latter being slightly higher. This slightly higher flow is probably due to the shorter average air path through the cotton to the plenum screen. Actual flow for the duct and plenum systems was 87 and 97 c.f.m. per square foot of free area, respectively.

For the push tests, the gate valve opening was reduced to 0.2 square foot to prevent cotton blowing from the bin with the exhaust air. In both duct and plenum arrangements, the load swelled on the moving air and cracked into channels that effectively short circuited most of the load.

Conclusions from these tests are that air can be moved through seed cotton on trailers most effectively by using a suction system with a plenum chamber of maximum free area.

Using a specially constructed wooden box with plenum chamber, Nissing [5] measured air volumes and static pressures for seed cotton at

[5] NISSING, T. J. RESISTANCE OF SEED COTTON TO AIR FLOW. Agr. Engin. 39(3): 160–163, 165. 1958.

1-foot intervals to a depth of 5 feet, and at densities of 6, 7, and 8 pounds per cubic foot (table 2). He concluded that power requirements to move a given quantity of air through 4 feet of seed cotton increased rapidly as density increased and that foreign matter and moisture content are important contributing factors.

Table 1.—*Cotton and air data for duct and plenum chamber system for moving air through seed cotton*

Item	Suction tests		Blow tests	
	Duct	Plenum	Duct	Plenum
Cotton data:				
Depth feet	4	4	4	4
Density per cubic foot pounds	7	7	7	7
Free surface square feet	160	160	160	160
Air data:				
Air system free area square feet	26. 7	47	26. 7	47
Air pipe area do	1. 4	1. 4	1. 4	1. 4
Gate valve opening do	1. 4	1. 4	. 2	. 2
Air moved c.f.m.	2, 324	4, 558	2, 425	2, 548
Approach velocity f.p.m.	14	28		
Static pressure inches water	21. 0	19. 8	6. 1	5. 2

Heating of Seed Cotton in Trailers

As each test lot (trailer load) arrived on the gin yard, it was parked under cover; thermocouples were installed and connected to a strip chart recorder. Eight thermocouples were located along the longitudinal axis of the trailer, four were located 2½ feet beneath the top of the load, and four were 2½ feet above the bottom of the load. Load depth was usually between 7 and 8 feet.

When the thermocouples showed that a stored lot of seed cotton was heating, air was pulled through the load until none of the thermocouples indicated a temperature higher than ambient.

Figure 3 illustrates the effect of forced-air movement on the temperature pattern of a 4-bale seed-cotton load that was warm on arrival. Moisture content of cottonseed going into storage was 14.4 percent. After 3 hours on the yard, the load's maximum temperature had dropped from 123° to 119° F. The fan was coupled to the trailer and was allowed to run for 2½ hours, at which time the maximum temperature measured was 80°. By the morning of the sixth day after fan cooling, the maximum temperature had slowly risen to 89°. Of 24 classing samples taken after 6 days' storage, none was downgraded because of fiber spotting. All were equal to, or better than, the eight before-storage samples (Strict Low Middling Plus).

Figure 4 illustrates the temperature changes of two 4-bale lots harvested simultaneously from the same field. Initial moisture content of the cottonseed was 16.4 percent. One lot was aerated immediately on arrival, whereas there was no effort to control heating in

TABLE 2.—*Resistance of seed cotton to air flow at three densities and five depths. Air flow is in terms of approach velocity (Va) and resistance is static pressure head in inches of water (Ps), against which air must move*

Density of seed cotton per cubic foot (pounds)	1 foot		2 feet		3 feet		4 feet		5 feet	
	Va	Ps	Va	Ps	Va	Ps	Va	Ps	Va	Ps
	Feet per minute	*Inches*	*Feet per minute*	*Inches*	*Feet per minute*	*Inches*	*Feet per minute*	*Inches*	*Feet per minute*	*Inches*
	11.86	0.50	11.86	0.70	23.55	2.60	11.86	1.00		
	24.72	1.40	16.70	1.30	40.28	5.10	26.39	3.60		
	36.24	2.30	31.23	3.10	52.78	7.80	40.92	5.70		
	47.27	3.30	45.77	5.30	60.79	9.80	52.95	8.40		
6	60.96	4.70	57.79	7.30	68.81	11.70	61.30	10.30		
	70.82	6.10	68.81	9.50	77.50	14.00	71.82	13.40		
	83.51	7.70	78.34	11.10	86.85	16.60	81.01	15.90		
	95.87	9.50	88.86	13.70	93.70	18.10	88.86	19.00		
			93.03	14.90						
	16.70	1.10	14.86	1.50	16.70	1.90	16.70	2.30	16.70	2.70
	26.40	2.00	20.38	2.30	20.38	2.60	20.38	3.00	25.39	4.50
	42.59	4.30	28.90	3.80	28.90	4.10	28.90	4.80	31.23	6.50
	50.11	5.30	44.10	6.00	37.25	5.80	37.41	6.50	40.92	8.60
7	60.30	6.10	54.12	8.10	50.11	8.30	50.11	9.50	50.11	11.00
	68.80	7.30	65.84	10.10	57.79	10.00	60.30	12.00	59.13	13.40
	77.16	8.30	70.82	11.30	69.82	13.10	70.82	14.50	65.81	15.10
	84.35	10.00	77.50	12.70	75.66	15.00	80.17	17.00	76.50	18.50
	93.70	11.20	87.52	14.80	88.36	18.60	86.85	19.00	80.17	19.30
	99.55	12.00	94.54	17.00						
	16.70	1.90	16.70	2.60	16.70	3.20	20.38	5.00	11.69	2.50
	20.38	2.80	33.40	7.00	28.90	7.10	31.23	8.20	20.38	5.50
	28.90	5.40	42.59	9.90	37.41	10.00	41.92	13.00	31.23	9.50
	40.92	7.90	48.60	12.20	45.76	13.40	48.77	15.50	40.92	13.50
8	48.77	10.80	61.30	17.60	52.78	15.70	52.78	17.80	45.76	15.50
	55.28	13.40	66.98	19.70	59.13	18.80	56.62	19.50	51.44	19.00
	60.30	15.00			63.94	20.00			54.12	20.00
	65.81	17.10								
	71.82	19.10								

Source: Nissing (see footnote 5).

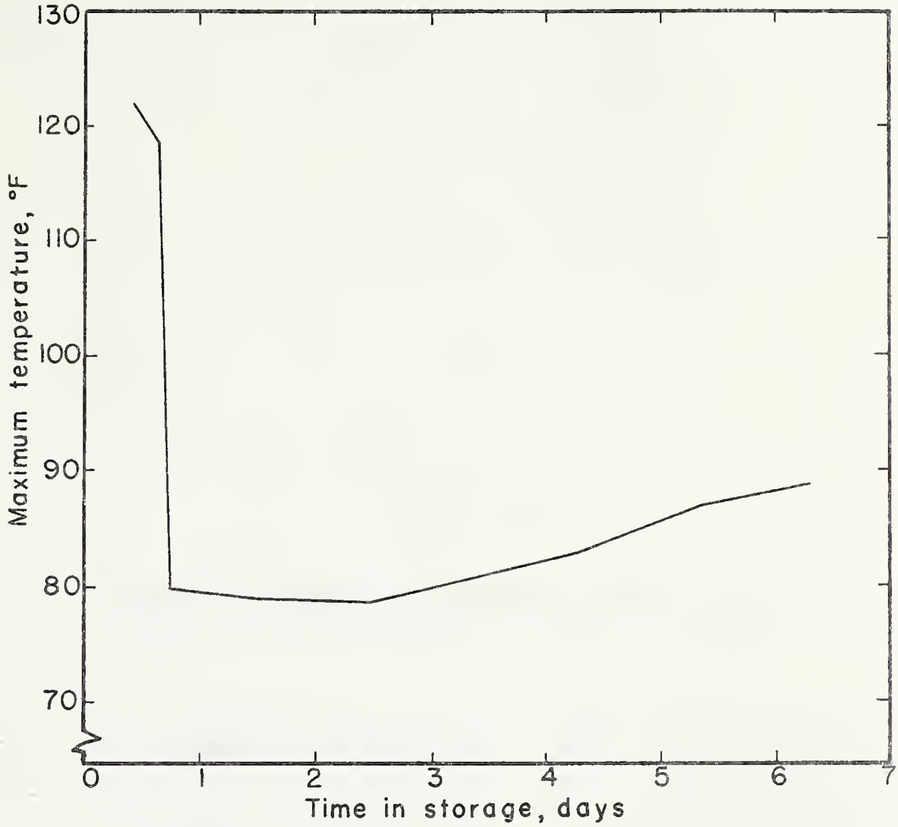

Figure 3.—Effect of suction aeration on temperature of 4-bale load of seed cotton during storage. Initial moisture content of cottonseed, 14.4 percent.

the check lot. Maximum temperature of the aerated lot dropped from 99° to 71° during the 4-hour air pull between 4:30 and 8:30 p.m.

Spontaneous heating continued and air was again pulled 2 days later. Maximum temperature was 106° before aeration, and 65° afterward. Air was pulled 1¾ hours, between 1:30 and 3:15 p.m. Temperature remained relatively constant for about 16 hours; then noticeable heating again occurred with maximum temperature reaching 102° on the morning of the seventh day, when the test ended.

The companion 4-bale load was not aerated during storage. Heating had already begun when the load arrived at the gin yard and continued at a declining rate until the maximum temperature of 139° was reached on the fourth day. Thereafter, the maximum temperature dropped slowly and was 133° at the close of the test on the seventh day.

A small quantity of seed cotton was ginned for lint classification when the trailers arrived for storage. Four of the ten samples were classified Strict Low Middling Light Spot. This classification indicates that 40 percent of the load was spotted when delivered to the gin. During after-storage ginning,

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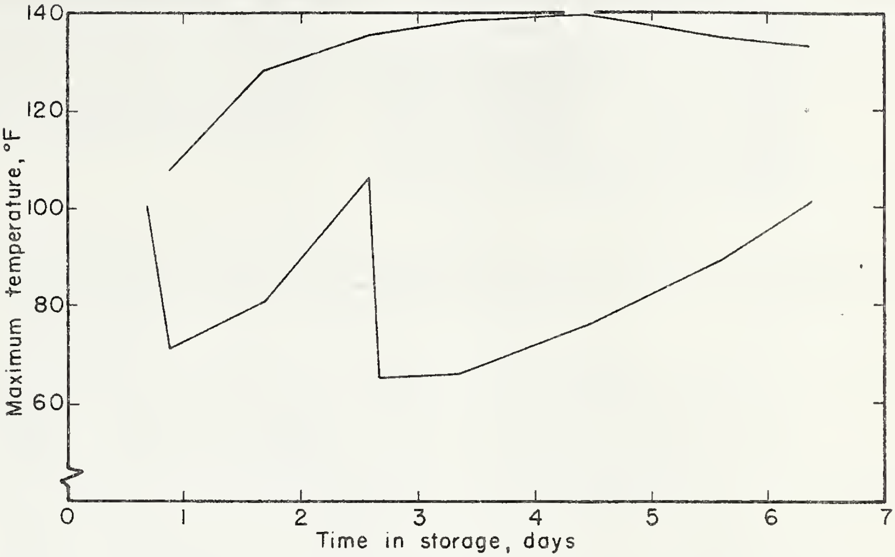

Figure 4.—Maximum temperatures of untreated (upper) and treated (lower) trailers of seed cotton. Treated load was aerated on arrival at gin and on third day of storage. Initial moisture content of cottonseed, 16.4 percent.

18 samples were taken from the aerated load for lint classification, and 12 were taken from the untreated load. All except one sample in each load was classified Strict Low Middling Light Spot, which indicated that each load was more than 90-percent spotted after storage. The increased spotting apparently was due to lint staining by pigments from the cottonseed coat.

A fermentation odor was observed within the untreated load but not within the aerated load during after-storage ginning. This odor was due to anaerobic (without gaseous oxygen) respiration. Since both loads contained ample moisture for biological activity of the seed to continue during the 7-day storage period, the rapid reheating rates of the aerated load may be attributed to aerobic (gaseous oxygen) respiration of the cottonseed continuing throughout the test. Carbon dioxide (one of the products of respiration) was replaced with fresh oxygen during periods of aeration, whereas anaerobic respiration occurred in the seed in the untreated load as the gaseous oxygen was used up, with a resulting decrease in rate of heat production.

In loading the bin in the field, the mechanical picker emptied successive pickings first into one-half of the bin and then into the other. This method of dumping insured against spilling cotton on the ground. In addition to the low-density area in the center of the trailer, low-density areas also existed at each end of the bin.

Figure 5 shows the temperature patterns within the aerated load. Figure 5, *B* and *D*, illustrates the

channeling effect of air being pulled through the lower density parts of the load.

Figure 6 depicts the temperature patterns in the untreated load.

The increase in moisture content in the lower parts of the aerated bin doubtless contributed to heating. During aeration, the conveying air absorbed moisture from the upper portion of the load. This was evidenced by temperature readings falling to lower than ambient as a

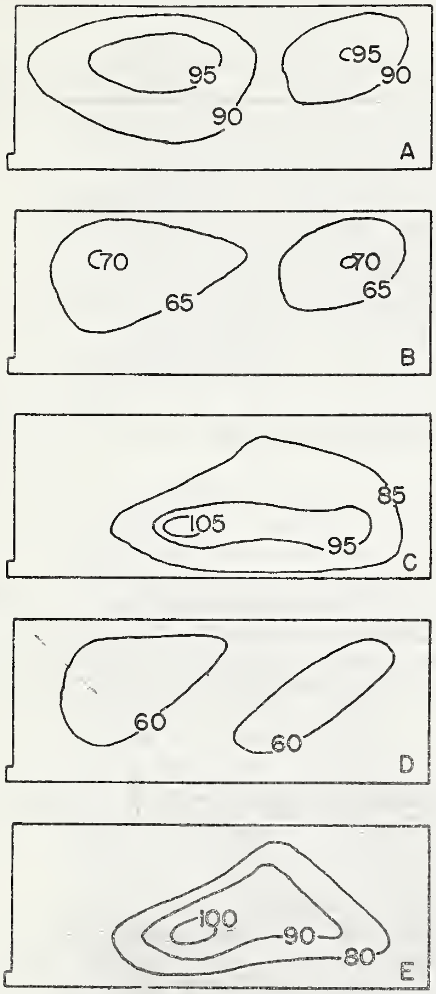

Figure 5.—Heat distribution in vertical plane through center of trailer of seed cotton treated twice by suction aeration: *A*, On arrival, first day of storage before suction aeration; *B*, first day, after 4 hours' suction aeration; *C*, third day, before suction aeration; *D*, Third day, after suction aeration; *E*, Seventh day, end of storage period.

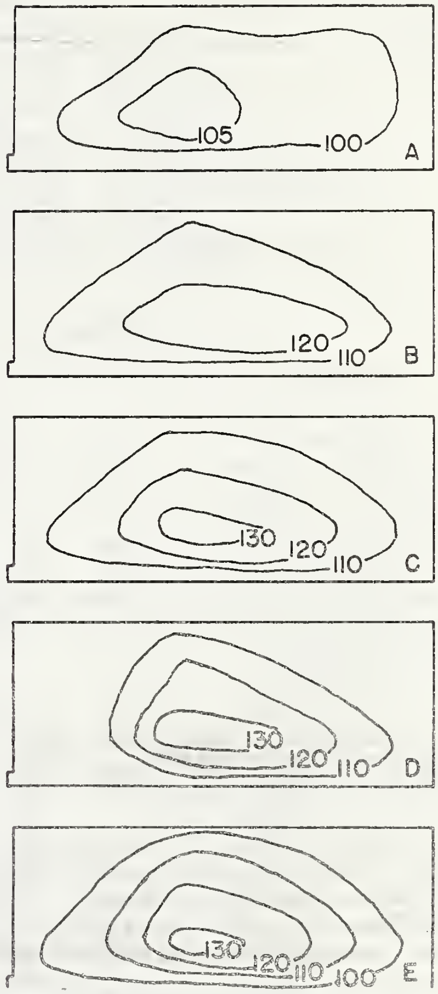

Figure 6.—Heat distribution in vertical plane through center of untreated trailer of seed cotton: *A*, On arrival, first day of storage; *B*, Second day; *C*, Third day; *D*, Fifth day; and *E*, Seventh day, end of storage period.

result of evaporative cooling during that period. When the fan was cut off, some of the moisture-laden air remained in the lower part of the load, thereby making more moisture available for absorption by the cottonseed (table 3).

At end-of-storage ginning, wet cotton was found matted against the bottom of the bin. Condensation occurred when the bin walls cooled at night below the dew point of the air in the bottom of the load. Condensation was also observed during other tests and led to the conclusion that trailers with open wall construction are more suitable than trailers with sheet-metal wall construction for seed-cotton storage in humid areas.

TABLE 3.—*Moisture content of cottonseed from suction aerated and nonaerated, 4-bale loads of seed cotton*

Sample identity	Moisture content of cottonseed
	Percent
Before storage	16. 4
Aerated load after storage:	
Lower rear	18. 1
Lower center	20. 0
Lower front	18. 0
Nonaerated load after storage:	
Lower rear	16. 1
Lower center	15. 6
Lower front	16. 1

Removing Moisture by Suction Aeration

Because the moisture content of cottonseed usually determines whether seed cotton may be stored safely and because aerating large lots with ambient air had not proved successful in preventing lint downgrading, a special investigation was made into the amount of drying to be expected by drawing air through seed cotton.

A square box with plenum chamber was constructed to hold cotton to a depth of 7 feet with a cross-section area of 30.5 square feet. The plenum chamber was created by installing a false floor of 12-gage wire mesh 18 inches above the bottom of the box. Free area of the wire floor was 16 square feet.

Twelve 84-pound lots of seed cotton were sprayed with water and blown into the box to provide 1,200 pounds of uniformly moistened cotton. As the box was being loaded, temperature and humidity sensing elements were placed 1 and 3 feet beneath the cotton surface. Total cotton depth was 4 feet.

The box was covered with a tarpaulin and left undisturbed for 3 days to permit the seed cotton to absorb moisture. During this period the moisture content of the cottonseed rose from 12 to 25 percent, and the temperature 1 foot beneath the surface rose from 74° to 122° F. On the third day, air was pulled through the load for a cooling and dehumidifying test. Air data showed the fan to be pulling air at 1,640 c.f.m. against a static pressure of nearly 20 inches of water. These data are similar to those obtained when air was pulled through the trailers fitted with triangular ducts. After 40 minutes, the load temperature 3 feet beneath the surface had dropped to approach air temperature, and the fan was allowed to run for an additional 12 minutes, making a total aeration period of 52 minutes.

The temperature and moisture sensing elements showed that the warm, trapped air was at or near saturation, and the maximum moisture removal was effected by re-

moving this warm air from the load. As ambient air (76° F., 86 percent relative humidity) moved into the load, the moisture-removal rate was considerably diminished, and dry bulb–wet bulb temperatures in the exhaust duct showed that little measurable moisture was removed after the load had cooled to the ambient air temperature. Moisture removed during the 52-minute period was 13.9 pounds, based on the area between approach and exhaust air humidity curves.

Two days later, warm air was pulled through the load for 2 hours. As the air entered the seed-cotton load, its temperature was quickly dropped by evaporative cooling and the relative humidity of the exhaust air was almost identical to that of the ambient air before heating.

Cotton samples taken after the test showed considerable drying at the load surface, a little drying 1 foot beneath the surface, and still less drying at the 3-foot depth (table 4).

These tests demonstrate the futility of attempting to dry damp cotton during periods of high humidity such as are found at night in the Mississippi Delta and during rainy periods. Because weather is an uncontrollable factor, drying of seed cotton in bulk storage is not considered a safe risk; and this points up the need to harvest cotton for storage during periods of low humidity.

These data also demonstrated the effect of cotton load density on drying and led to tests on prestorage methods of drying.

TABLE 4.—*Moisture content of seed cotton, fiber, and cottonseed as affected by suction aeration* [1]

Sample identity	Moisture content of—		
	Seed cotton	Fiber	Cottonseed
	Percent	*Percent*	*Percent*
Raw cotton before moistening and storage	11. 6	9. 2	12. 0
On 5th day of storage before 2-hour warm air treatment, top of load	21. 2	14. 3	23. 8
After 2-hour warm air treatment:			
Surface of load	12. 2	6. 5	13. 8
1 foot beneath surface	20. 4	11. 4	21. 2
3 feet beneath surface	21. 0	13. 5	23. 4

[1] 1,640 c.f.m., or 54 c.f.m. per square foot of surface. Cotton 4 feet deep in test box with plenum chamber.

Drying Seed Cotton Before Trailer Storage

After determining that drawing ambient air through trailer loads of seed cotton had virtually no effect on the moisture content of the seed and that impervious trailer wall construction contributed to moisture condensation within the trailer, further investigations were made to determine (1) the feasibility of field drying after harvesting and (2) the feasibility of transferring cotton from one trailer to another through a gin-type drying system.

In one test, seed cotton was transferred from one trailer to another

by using ambient air only. A second lot was routed through the gin drier during the transfer process. Transfer rate was approximately 100 pounds of cotton per minute. The ambient-air treatment removed about 1 percent of moisture from the fiber and had no effect on seed moisture (table 5). In the gin-dried lot, moisture was reduced more than 4 percent in the fiber and 0.7 percent in the seed. During the 40-hour storage period, the moisture content of the seed in the lot dried by ambient air dropped to 18.4 percent, whereas that of the seed in the gin-dried lot dropped to 16.3 percent. As a result of this test, ambient-air drying was discontinued.

The final series of three seed-cotton storage tests was run with the following variables: (1) Undried, stored in sheet-metal trailer; (2) undried, stored in expanded-metal trailer; (3) gin dried after delivery to gin and redeposited on trailer in a continuous operation; and (4) field dried after harvesting by spreading on wire rack for 1 hour before loading on trailer. The storage period was 72 hours. Trailers used in these tests are shown in figure 7.

Tests showed no appreciable difference in moisture content of the field-dried and the undried lots stored in sheet-metal and expanded-metal trailers. Moisture content of the cottonseed averaged 3 percent less in gin-dried lots than in the other three test lots (table 6).

Heating patterns during storage were similar for the two undried lots (fig. 8). One difference between these treatments observed after storage was that condensation had occurred within the sheet-metal trailer while no evidence of condensation was found within the expanded-metal trailer. Although tests failed to show significant moisture differences between field-dried and undried lots, the field-dried lot definitely exhibited a lower tendency to heat than did the undried lots. The gin-dried lot entered storage with some residual heat from the drier, but it cooled continuously and at the end of the storage period it had the lowest temperature of the test lots.

Samples were taken for lint classification before and after storage. None of the 18 before-storage samples were classified as Light Spot (table 7). Each of the storage treatments yielded lint classified as Light Spot or Full Spot.

TABLE 5.—*Moisture content data for cotton unloaded with ambient air and with heated air, and stored 40 hours in 1-bale, sheet-metal trailers* [1]

Sample history	Moisture content of—		
	Seed cotton	Fiber	Cottonseed
	Percent	*Percent*	*Percent*
As delivered to gin	18.4	12.0	18.9
Ambient drying:			
Enter storage	18.3	11.0	18.9
After storage	16.2	10.4	18.4
Gin drying:			
Enter storage	15.4	7.7	18.2
After storage	14.9	8.9	16.3

[1] Ambient air, 79° F. and 55 percent RH. Gin drier temperature, 300° F. at air-cotton mix point.

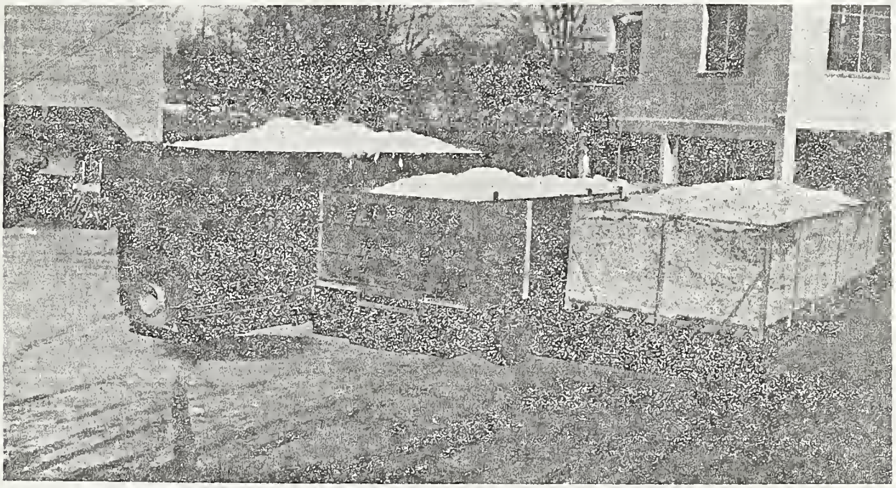

Figure 7.—Types of trailers used in seed-cotton storage studies.

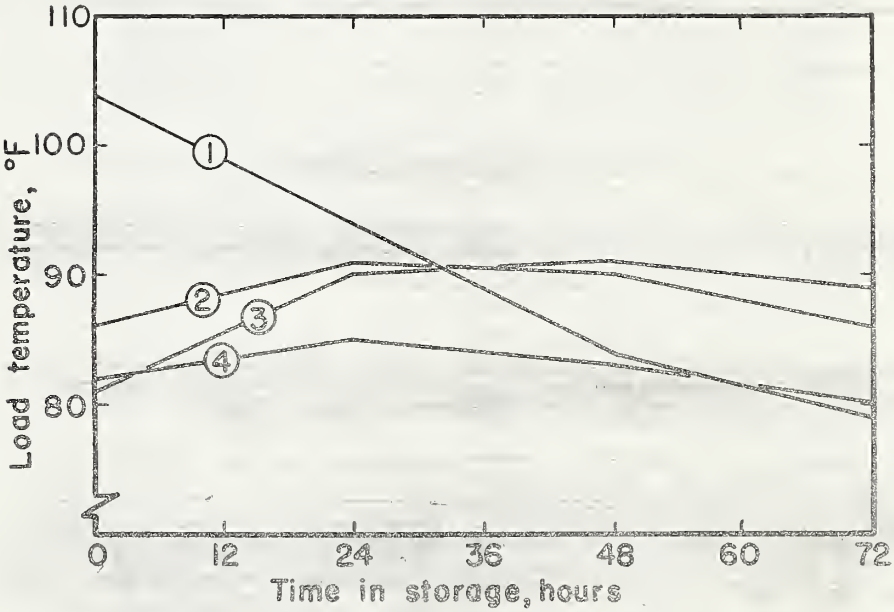

Figure 8.—Temperatures of mechanically picked seed cotton stored in trailer for 72 hours: (1) Unloaded through gin drier and reloaded on trailer; (2) untreated, stored in sheet-metal trailer; (3) untreated, stored in expanded-metal trailer; and (4) spread on wire rack in cotton field for 1 hour before loading on trailer.

After-storage samples from the gin-dried and field-dried lots were graded higher than samples from either of the undried lots. The undried cotton stored in the sheet-metal trailer suffered the greatest in-storage grade damage.

A distinct disadvantage of sheet-metal walls compared to mesh walls for trailers was the wetting of cotton by moisture that condensed on the inner surface of the trailer when its temperature dropped below the dew point of the entrained air.

TABLE 6.—*Moisture content data for cotton stored under three drying conditions and in two types of trailers*

Sample history	Moisture content of—		
	Seed cotton	Fiber	Cottonseed
	Percent	*Percent*	*Percent*
As delivered to gin	15. 5	11. 6	16. 5
Undried, in sheet-metal traliers: After storage	15. 9	10. 4	16. 8
Undried, in expanded-metal trailer: After storage	15. 4	10. 0	16. 3
Gin dried: [1]			
Enter storage	13. 0	7. 8	13. 4
After storage	12. 9	9. 2	13. 4
Field dried: [2]			
Enter storage	14. 2	11. 0	13. 4
After storage	15. 6	10. 6	16. 3

[1] Gin drier temperature 325° F. at air-cotton mix point.
[2] 1-hour exposure on wire racks after picking.

TABLE 7.—*Distribution of lint grades of cotton, 1958 trailer storage tests*

Lint grade designation and index	As delivered	After storage			
		Gin dried	Field dried	Undried	
				Metal trailer	Mesh trailer
White grades:	*Number*	*Number*	*Number*	*Number*	*Number*
M+ (102)	2	3	0	0	0
M (100)	7	4	3	4	6
SLM+ (97)	3	1	6	1	1
SLM (94)	6	0	2	0	0
Light Spotted grades:					
M (97)	0	8	4	6	7
SLM (93)	0	2	3	7	1
Spotted grades:					
SLM (88)	0	0	0	0	3
Total, all grades	18	18	18	18	18
Average grade index	97. 9	97. 6	95. 8	94. 6	95. 2
Average grade designation	SLM+	SLM+	SLM+	SLM	SLM

Effect of Trailer Storage Tests on Fiber and Spinning Quality

Several varieties of cotton were used in carrying out tests under this project, and they represented many preharvest field and growth conditions. Consequently, no attempt was made to combine the fiber and spinning data from all lots. Rather, two tests were selected to represent the variations encountered; the results are presented in tables 8 and 9. Most of the variability is within laboratory testing limits. Lack of definite trends, except for lint grade, is in part due to natural blending of the seed-cotton load during the ginning processes. Even though efforts were made to secure ginned lint samples from specific portions of the test loads, considerable blending of the cotton as it passed through the machinery could not be prevented. Thus, these data probably do not represent maximum storage effects to parts of the load, but they do provide information for predicting effects that may be found under actual storage and ginning conditions.

Effect on Fiber Length.—Fiber length was not appreciably affected by storage. Measured variations in length are attributable to variations in moisture content of the fiber during ginning and to error in measuring.

Effect on Fiber Strength.—Variations in measurements of fiber tensile strength were usually small and inconsistent. More often than not, loads that heated during storage showed slight losses in fiber strength.

Effect on Fineness and Maturity.—Fineness and maturity are determined by varietal characteristics and growth environment and thus are not subject to change after the boll opens.

Effect on Lint Grade.—Almost without exception, lots that heated during storage yielded ginned lint of lower grades after storage than before. Downgrading was usually due to a higher percentage of after-storage samples being classified as Light Spot or other inferior color designation as compared with before-storage samples. Examination of the test lots when delivered (before storage) and during ginning (after storage) ruled out in-storage spotting from dust, dirt, grease, bacteria, and insects. Some of the cotton had suffered insect or field-weathering damage before harvesting. It is believed that in-storage fiber spotting was due to the cottonseed coat breaking down under high moisture and temperature conditions and that tanniferous polyphenolic pigments from the cottonseed coat were absorbed by the fiber.[6]

Special attention was given the problem of whether color downgrading of ginned lint could be due to transfer of chlorophyll pigment from green leaf fragments during storage. Many machine-picked loads of cotton contained green stains caused by leaves being crushed against cotton by the spindles in the picker. Within a few days these green chlorophyll spots turned brown and were a source of "spots" in ginned lint. During after-storage ginning of these lots, the authors climbed into

[6] Gregory, Luis E. Crops Research Division, Agricultural Research Service, U.S. Dept. of Agriculture. Personal communication.

the trailers and examined the loads for cotton and leaf fragments in intimate contact. In most instances, fiber staining was not evident when the leaf was carefully lifted from the cotton. In a very few instances, a very faint outline of the leaf at its torn edge could be distinguished in the cotton. However, the frequency and intensity of coloration was so slight that transfer of chlorophyll from uncrushed green leaf fragments to cotton fibers is not considered a serious hazard in seed-cotton storage.

Effect on Picker and Card Waste.—Picker and card waste variations due to treatment were usually small and without pattern except in lots gin dried for storage. These lots showed slightly less manufacturing waste because of the extra foreign matter removed during prestorage drying.

Effect on Neps in Card Web.—Tables 7 and 8 contain data on the largest nep variations found in the tests. Some of the after-storage lots showed fewer neps than the before-storage lots. Generally, when the neps in the before-storage lots ranged from 15 to 25, the after-storage lots showed an increase of fewer than 10 neps.

Effect on Ends Down.—Spinning end breakage on all lots spun was reported as low.

Effect on Yarn Strength.—The average factor for 22's and 50's yarns showed only normal variability for most of the test lots when fiber moisture content during gin-

Table 8.—*Effect of 6 days' storage of machine-picked cotton, untreated and suction aerated, on moisture content, lint classification, fiber, and spinning quality elements* [1]

Item	Before storage	After storage	
		No treatment	Aerated twice
Moisture content data:			
Seed cotton percent	15. 8	14–16	17–19
Fiber do	11. 7	10. 0	8–11
Cottonseed do	16. 4	15–16	13–20
Ginned lint do	5. 8	4. 4	3. 2
Lint classification data:			
Light Spot to total grades ratio	4:10	17:18	11:12
Grade designation	LM+ to M	SLM	SLM
Staple length 1/32-inch	34. 0	34. 0	34. 0
Fiber data:			
Upper half mean length inches	1. 16	1. 14	1. 13
Uniformity ratio index	76	76	76
Tensile strength 1/8 ga. index	102	95	97
Fineness	3. 9		
Maturity	77		
Spinning data: [2]			
Picker and card waste percent	10. 53	10. 66	10. 41
Neps per 100 sq. in. card web	20	34	25
Spinning end breakage	Low	Low	Low
Yarn break factor	2178	2082	2123
Yarn appearance index	95	82	92

[1] 4-bale loads stored in metal-wall trailers.
[2] Yarn Nos. 22 and 50.

ning and upper half mean length are taken into account. The most severe spontaneous heating conditions, coupled with fiber length reductions due to ginning, gave a yarn strength reduction of less than 5 percent.

Effect on Yarn Appearance.—Yarn appearance generally showed only minor variations with storage treatment. Cottons subjected to prolonged high temperature storage periods showed the greatest tendency for lowered yarn appearance.

Table 9.—*Effect of 7 days' storage of machine-picked cotton, untreated and gin-dried before storage, on moisture content, lint classification, fiber, and spinning quality elements* [1]

Item	Before storage	After storage	
		No treatment	Gin dried
Moisture content data:			
Foreign matter ... percent	41. 6	19. 3	11. 2
Seed cotton ... do	10. 7	13. 0	8. 6
Fiber ... do	10. 9	8. 6	4. 5
Cottonseed ... do	14. 5	14. 0	7. 6
Ginned lint ... do	3. 5	3. 6	3. 3
Lint classification data:			
Light Spot to total grades ... ratio	0:8	3:12	0:12
Grade designation	M+	M	SM
Staple length ... 1/32-inch	32. 1	32. 2	32. 0
Fiber data:			
Upper half mean length ... inches	. 95	. 99	. 96
Uniformity ratio ... index	78	79	80
Tensile strength ... do	96	96	94
Spinning data: [2]			
Picker and card waste ... percent	8. 80	9. 89	8. 44
Neps ... per 100 sq. in. card web	27	50	46
Spinning end breakage	Low	Low	Low
Yarn break factor	2330	2296	2264
Yarn appearance ... index	75	75	75

[1] 1½-bale loads.
[2] Yarn Nos. 22 and 50.

Summary

Preventing fiber color loss is the major problem in storing seed cotton in trailers. Color losses are reflected in lowered lint grades that reduce the cash value of the cotton.

These studies showed that cottonseed undergoes biological processes during seed-cotton storage similar to those it undergoes in bulk storage, and that the moisture content of the cottonseed largely determines whether a load of seed cotton may be safely stored or whether it will heat and suffer grade damage. Storage of seed cotton on trailers can be considered safe only if the seed does not contain or will not absorb sufficient moisture for biological activity resulting in heat being produced faster than it can be dissipated.

The division between safe and unsafe cottonseed moisture contents for seed-cotton storage is not sharp. Results of these seed-cotton investigations agree with results Robert-

son and Campbell [7] obtained when studying cottonseed heating and led to the conclusion that storage of seed cotton in trailers (or any other bulk enclosure) may be considered safe if the cottonseed moisture content is below 10 percent; seed cotton with seed moisture content of 11 to 13 percent may or may not be safely stored; and seed cotton with seed moisture above 13 percent may be expected to heat in bulk storage with resulting damage to fiber color.

In these investigations the principal methods of treating seed cotton for trailer storage were (1) forced air aeration, (2) field drying, and (3) transferring cotton from one trailer to another through a gin-drying system.

Cooling and drying trailer loads of seed cotton by forced aeration was too slow and unreliable to be a practical means of preventing storage damage on a commercial scale. Suction aeration was used to cool trailer loads of seed cotton, but in most instances did not prevent reheating. Maximum temperature recorded during the tests was 139° F. This temperature was reached on the fourth day of storage of a 4-bale load of machine-picked cotton that received no cooling or drying.

Drying machine-picked cotton in the field by spreading it on wire racks provided some reduction in storage damage as compared to untreated cotton, but the number of racks and cost of labor make this treatment uneconomical.

Transferring machine-picked cotton from one trailer to another with either ambient or heated air gave adequate drying for safe storage when the seeds were dry and moisture to be removed was principally in the fiber. The heated-air treatment must be used with caution because cotton with high-moisture seed, unless cooled after drying, will go into storage under conditions ideal for rapid seed respiration and spoiling.

Mesh walls for cotton storage bins were found to be superior to sheet-metal walls because moisture in the trapped air condensed and wetted cotton touching the walls. The same result would be expected of storage facilities made of rubberized or plastic sheet material that does not allow free moisture transfer.

Storing seed cotton in trai[illegible]s did not significantly affect f[illegible] spinning quality elem[illegible]pt for the color factor of lint [illegible], unless severe heating of the load developed. Loss of color was simple dulling in some cases and in others was due to pigments from the seed coat staining the adjacent fibers. Fiber discoloration by transfer of chlorophyll from uncrushed green leaves was found to be only a minor hazard in seed-cotton storage.

[7] See footnote 2, p. 2.

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